

Modelling the water isotopes with the global cloud-system-resolving model: Evaluation against site observation and gridded dataset

Masahiro Tanoue¹, H. Yashiro¹, Y. Takano², K. Yoshimura³

¹ National Institute for Environmental Studies, Tsukuba 305-8506, Japan
² Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, 277-8564, Japan
³ Institute of Industrial Science, The University of Tokyo, Kashiwa, 277-8564, Japan



Summary

- A global cloud-system-resolving model equipped with stable water isotopes (SWIs), namely **NICAM-WISO**, is developed.
- We validated precipitation isotopic ratios simulated by the model.
- However, **the model overestimated precipitation d-excess in continental regions** (Figure 2).
- The above overestimation was occurred for **vapor deposition process in ice cloud with low ice water content** (Figure 4).
- SWIs revealed model's biases related to atmospheric hydrological cycle and cloud microphysics.

Methods

- Model: **NICAM** (Satoh et al., 2014)
- Cloud scheme:
 - **Single-moment cloud microphysics** scheme (Tomita, 2008; Roh et al., 2014)
 - Six category water (Figure 1)
- Convective scheme: NONE
- Simulation:
 - Horizontal resolution: 56 km
 - Vertical levels: 78 layers
 - Simulation period: 1979–1990

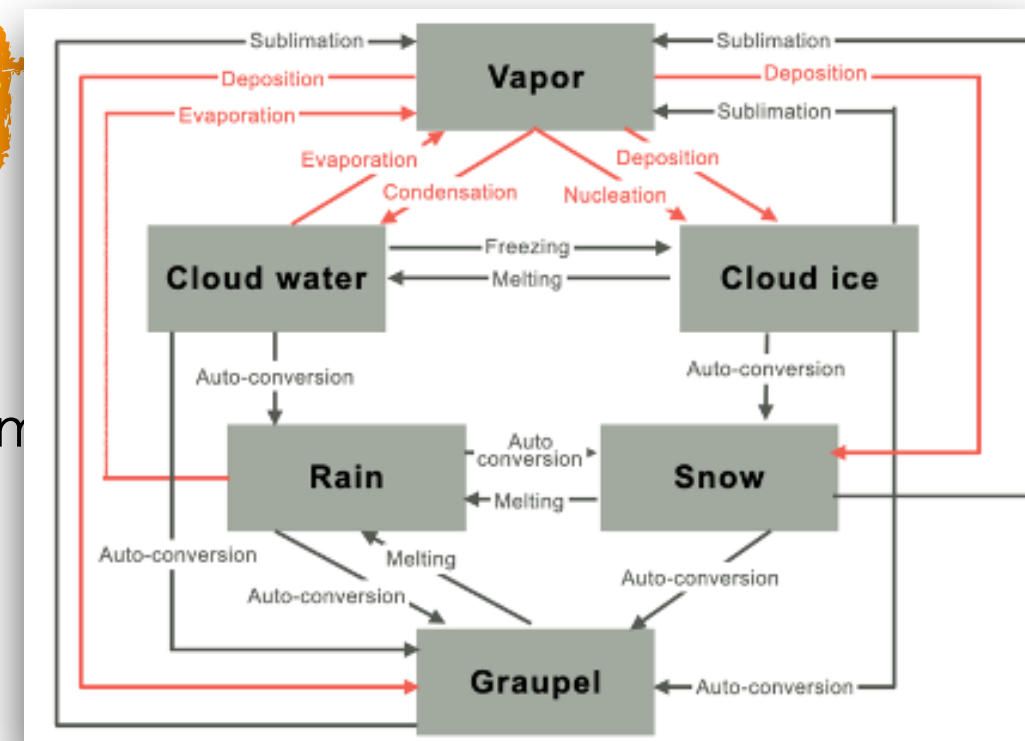


Figure 1. Conversion diagram for NICAM-WISO. Gray and dark gray indicates prognostic and diagnostic variables, respectively. Red arrows indicate isotopic fractionation occurs, while black arrows indicate no isotopic fractionation.

Results and discussion —precipitation d-excess for DJF—

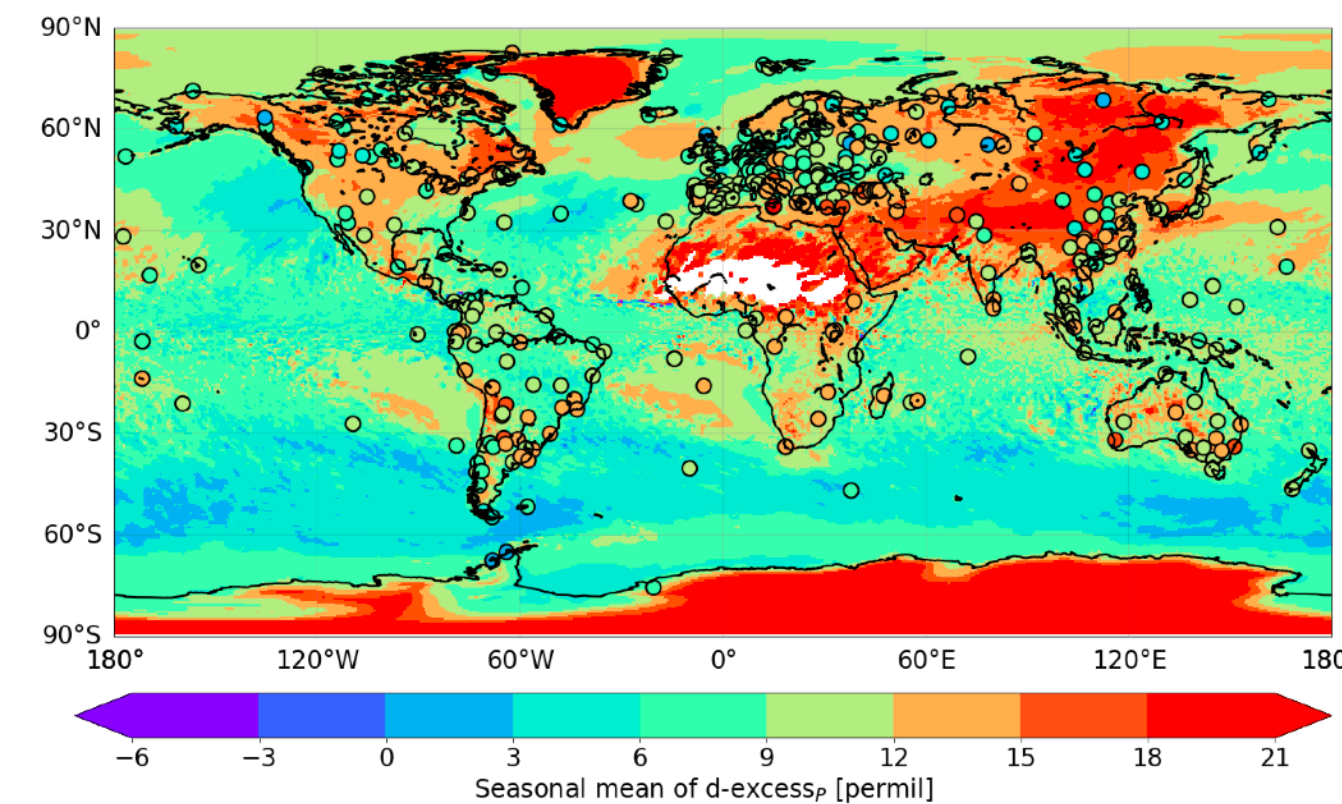


Figure 2. DJF mean of precipitation d-excess (‰). Shaded and plots indicates the model and GNIP observation, respectively.

- The model **overestimated d-excess** in continental regions:
 - Greenland, Siberia and Antarctic
 - Middle East, Sahel
- **The above continental regions:**
 - Dominant ice cloud (low F).
 - Small IWC
- > The overestimation is related to ice cloud with small IWC.

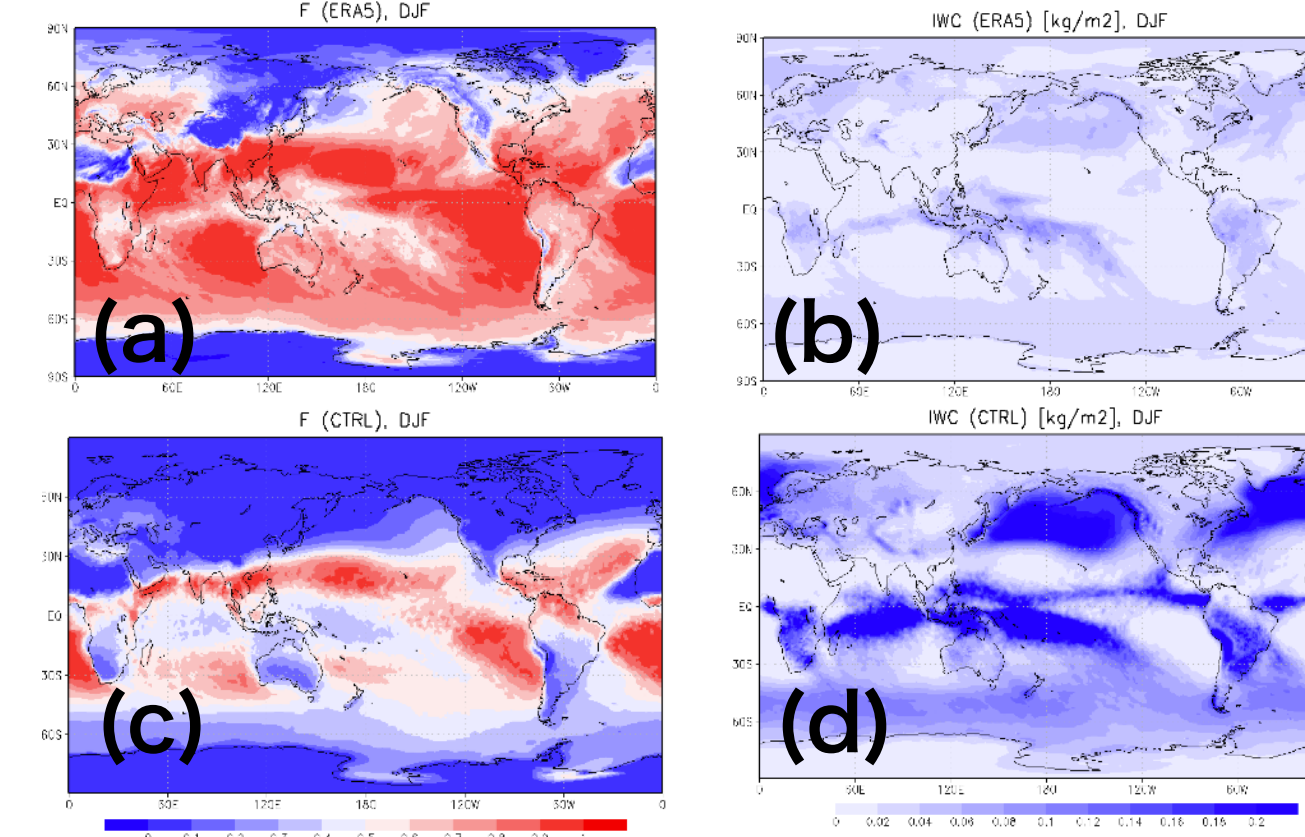


Figure 3. DJF mean of F (the ratio of mass fraction of liquid cloud to the sum of liquid and ice clouds) (a and c) and ice water content (IWC) (b and d) for ERA5 (a and b) and the model (c and d).

- Relationship d-excess and F or IWC
 - A large d-excess is occurred in ice cloud with small IWC.
- > Uncertainty in vapor deposition process in ice cloud

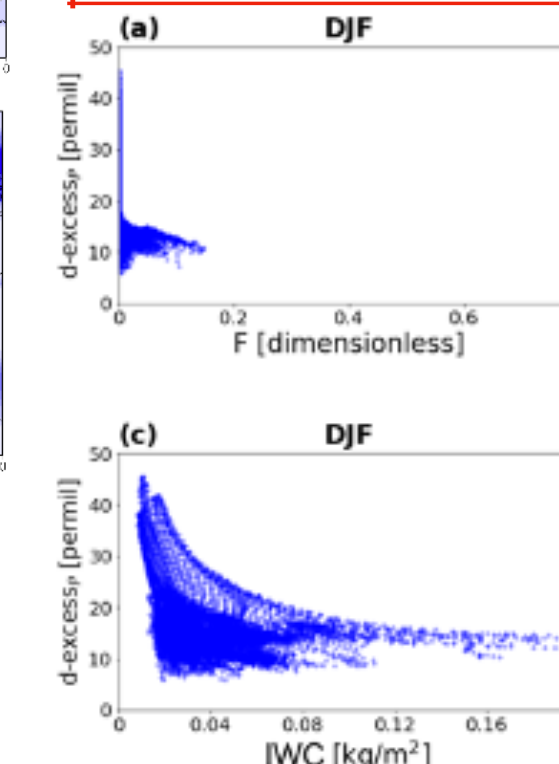


Figure 4. (a) Relationship between simulated precipitation d-excess and F for the grids with $> 60^\circ \text{N}$ for DJF. (b) Relationship between simulated precipitation d-excess and IWC for the grids with $> 60^\circ \text{N}$ and $F < 0.01$ for DJF.